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Sick Body, Vigilant Mind: The Biological Immune System Activates the Behavioral Immune System

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Abstract

Activation of the behavioral immune system has been shown to promote activation of the biological immune system. The current research tested the hypothesis that activation of the biological immune system (as a result of recent illness) promotes activation of the behavioral immune system. Participants who had recently been ill, and had therefore recently experienced activation of their biological immune system, displayed heightened attention to (Study 1) and avoidance of (Study 2) disfigured individuals—cognitive and behavioral processes reflecting activation of the behavioral immune system. These findings shed light on the interactive nature of biological and psychological mechanisms designed to help people overcome the threat of disease.

Keywords

attention, avoidance, threat, health, social cognition

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People are equipped with a biological immune (BIO) system, designed to destroy pathogens that have entered the body, and a behavioral immune (BEH) system, designed to prevent people from coming into contact with infected others (Neuberg, Kenrick, & Schaller, 2011; Schaller & Duncan, 2007; Schaller & Park, 2011). These two systems interact with one another. Recent findings suggest that activation of the BEH system promotes activation of the BIO system: Viewing disease cues (skin lesions, someone sneezing) led people to display a heightened biological immune response (i.e., stimulated production of cytokine interleukin-6; Schaller, Miller, Gervais, Yager, & Chen, 2010). In this report, we provide the first evidence for the converse: Activation of the BIO system promotes activation of the BEH system.

The BEH system consists of cognitive, affective, and behavioral processes that facilitate detection and avoidance of potential disease carriers. People quickly notice morphological and behavioral cues of infection (e.g., rashes, sneezing), and they display affective (disgust) and behavioral (avoidance) reactions to those cues (Ackerman et al., 2009; Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010; Oaten, Stevenson, & Case, 2009; Tybur, Lieberman, & Griskevicius, 2009). Studies have demonstrated that the BEH system is activated by stimuli that explicitly prime concerns about disease (e.g., telling people that they are at risk for contracting diseases increases their vigilance to heuristic disease cues; Duncan & Schaller, 2009; Park, Faulkner, & Schaller, 2003; Park, Schaller, & Crandall, 2007). In the experiments reported here, we tested the novel hypothesis that the BEH system becomes engaged when the BIO system has been activated through illness (cf. Fessler, Eng, & Navarrete, 2005).

The BIO system is imperfect. In response to microbial intruders, cytokines produce an inflammatory response designed to rid the body of those intruders. However, chronic inflammation can lead to severe tissue damage. Consequently, after an inflammatory response, other cytokines produce an anti-inflammatory response (Mocellin, Panelli, Wang, Nagorsen, & Marincola, 2003). Although useful for helping the body recover after infection, the anti-inflammatory response may be detrimental if other microbial intruders enter the body during that period. That is, in producing an anti-inflammatory response, the BIO system temporarily lowers the body's defenses against new pathogens. Thus, when the BIO system fights off one pathogen, the body temporarily experiences susceptibility to new pathogens (Le Vine, Koeningsknecht, & Stark, 2001; Zhang et al., 1996). For instance, production of the cytokine interleukin-10, part of the BIO system's anti-inflammatory response, causes enhanced susceptibility to secondary bacterial infections after influenza infection (van der Sluijs et al., 2004).

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Because fighting off one disease can temporarily increase susceptibility to other diseases, we predicted that recent activation of the BIO system would promote activation of the BEH system. Through activation of the BEH system, people would be less likely to contract infectious diseases during a period in which their body is relatively susceptible to new pathogens. In two studies, we tested the hypothesis that activation of the BIO system (due to recent illness) promotes activation of the BEH system, as reflected by heightened attention to (Study 1) and avoidance of (Study 2) people displaying heuristic disease cues.

Study 1

Study 1 tested the hypothesis that recent illness is associated with attentional biases reflecting activation of the BEH system. Because contagious diseases can produce physical deviations from the morphological norm, the BEH system promotes attention to people displaying nonnormative physical attributes, such as facial disfigurement (Ackerman et al., 2009). Thus, we predicted that participants who had recently been ill (and therefore experienced recent activation of the BIO system) would attend more to disfigured faces than to normal faces. To rule out the possibility that any observed effects were driven merely by the conscious accessibility of disease concerns after illness, we also measured and controlled for people's explicit concerns about vulnerability to disease.

Method

Participants. Ninety-six undergraduates (ages 18–30; 60 women, 36 men) participated.

Materials and procedure. To measure attentional biases, we asked participants to perform a visual dot probe task (e.g., Maner, Gailliot, Rouby, & Miller, 2007). Target stimuli consisted of 40 facial photographs (20 disfigured, 20 normal) used in previous research (see Ackerman et al., 2009, for a description of the stimuli).

On each trial, a face was displayed for 500 ms in one quadrant of the computer screen. When the face disappeared, a categorization object (circle or square) immediately appeared in either the same location as the face (filler trials) or a different quadrant (attentional-shift trials). Participants indicated as quickly as possible via key press whether the object was a circle or square. Larger latencies on attentional-shift trials represented greater attention to the previous target face; that is, participants were slower to shift their attention away from the location of the face to the location of the object. After completing 12 practice trials (with neutral items instead of faces), participants completed 80 experimental trials (40% filler and 60% attentional-shift trials). Each face was displayed twice.

We assessed illness recency with both continuous and categorical measures. For the continuous measure, participants indicated their agreement (1 = *strongly disagree*, 7 = *strongly agree*) with four statements: "Over the past couple days, I have not been feeling well"; "Lately, I have been feeling a little under the weather"; "I have felt sick within the past week"; and "I had a cold or flu recently." Average scores were calculated ($\alpha = .86$). For the categorical measure, participants indicated the last time they had a cold by selecting from among the following response options: "today," "a couple days ago," "a week ago," "a couple weeks ago," "a month ago," "a few months ago," and "a year or more ago." Participants were categorized into two groups: a recently ill group (those who responded with one of the first three options) and a not recently ill group (those who responded with one of the other options). This categorization reflects the typical window of the BIO system's heightened susceptibility to new diseases after infection (Jakab, 1985). (See the Supplemental Material available online for results using an alternative categorization scheme.)

To assess conscious concerns about disease, we had participants complete the subscales of the Perceived Vulnerability to Disease scale (Duncan, Schaller, & Park, 2009). The Germ Aversion subscale measures discomfort toward disease-connoting situations. The Perceived Infectability subscale measures beliefs about susceptibility to infectious diseases. Average scores were calculated for each subscale ($\alpha = .82$ and $\alpha = .87$, respectively).

Results and discussion

Trials with incorrect categorization responses and trials with latencies greater than 3 standard deviations above or below a participant's mean latency were excluded. Two participants had high error rates (> 3 *SD* above the mean) and were excluded. All measures approximated a normal distribution.

Average reaction time on attentional-shift trials was analyzed using an analysis of variance with factors of target disfigurement (normal vs. disfigured; within subjects) and illness recency (the categorical measure: recently ill vs. not recently ill; between subjects). We found a significant interaction between illness recency and target disfigurement, $F(1, 92) = 9.63$, $p = .003$, $\eta_p^2 = .10$. Participants who had been ill within the past week ($n = 28$) attended more to disfigured faces ($M = 651$ ms, $SD = 180$) than to normal faces ($M = 613$ ms, $SD = 142$), $F(1, 92) = 11.06$, $p = .001$, $\eta_p^2 = .11$; participants who had not been recently ill ($n = 66$) displayed no attentional bias, $F < 1$ (disfigured faces: $M = 618$ ms, $SD = 163$; normal faces: $M = 622$ ms, $SD = 182$).

Analysis using the continuous measure of illness recency revealed a similar interaction between target disfigurement and illness recency, $F(1, 92) = 3.07$, $p = .08$, $\eta_p^2 = .03$. Simple-slopes analyses revealed that participants who had been recently sick (1 *SD* above the mean on the illness-recency measure; $M = 2.86$, $SD = 1.68$) attended more to disfigured than to normal faces, $F(1, 92) = 4.61$, $p = .03$, $\eta_p^2 = .05$. Participants who had not been recently sick (1 *SD* below the mean) did not show this effect, $F < 1$ (see Fig. 1).

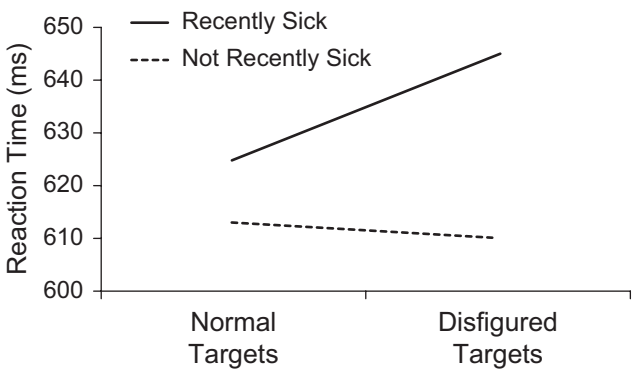

Fig. 1. Results from Study 1: mean reaction time on attentional-shift trials in the dot probe task as a function of target type (normal vs. disfigured face) and continuously measured illness recency (recently sick = 1 *SD* above the mean; not recently sick = 1 *SD* below the mean).

Ancillary analyses revealed no correlation between the continuous measure of illness recency and the measures of germ aversion and perceived infectability, *p*s > .40. Nor did germ-aversion or perceived-infectability scores discriminate between participants who had and had not been ill within the past week, *F*s < 1. The interactions between target disfigurement and illness recency remained marginally significant after controlling for those measures, *p*s < .07. Thus, the link between recent illness and attentional bias was not due to conscious disease concerns.

Elevated attention to physical abnormalities is a cognitive process linked to the BEH system (Ackerman et al., 2009). Thus, independently of conscious concerns about disease, recent activation of the BIO system (indicated by recent illness) was associated with an attentional bias reflective of BEH-system activation.

Study 2

Study 2 tested the hypothesis that recent illness is associated with increased avoidance of and decreased approach toward disfigured individuals. Evidence indicates that muscle extension (pushing a lever) represents an avoidance response, whereas muscle flexion (pulling a lever) represents an approach response (Chen & Bargh, 1999; Förster, Friedman, Özelsel, & Denzler, 2006). Additionally, research suggests that the BEH system promotes greater avoidance responses relative to approach responses (Mortensen et al., 2010). Thus, we predicted that recently ill participants would be quicker to engage arm movements congruent with avoidance of disfigured individuals (pushing a lever) than to engage arm movements congruent with approach toward disfigured individuals (pulling a lever). As in Study 1, we predicted that this effect would be over and above the effect of explicit disease concerns.

Method

Participants. One hundred seven undergraduates (ages 18–35; 79 women, 28 men) participated. One participant failed to complete all measures; her data were excluded.

Materials and procedure. Following previous methods (Chen & Bargh, 1999), we randomly assigned participants to one of two movement conditions: a bias-congruent condition, in which they pushed a joystick away from themselves (avoidance behavior) in response to disfigured faces and pulled a joystick toward themselves (approach behavior) in response to normal faces, or a bias-incongruent condition, in which they did the reverse (pulled the joystick for disfigured faces and pushed it for normal faces). Participants were instructed to move the joystick as quickly as possible. The dependent variable was average reaction time to complete joystick movements.

Target stimuli consisted of eight faces (four disfigured, four normal) from Study 1. During each trial, a central fixation point appeared for 2,500 ms and was immediately followed by a target face. Target faces remained on the screen until participants moved the joystick. After completing 16 practice trials in which they moved the joystick in response to the words "PUSH" and "PULL," participants completed the experimental trials. Target stimuli were presented in random order, and each face was presented four times (32 trials in total). After the approach-avoidance task, participants completed the continuous ($\alpha = .87$) and categorical measures of illness recency used in Study 1 and the Germ Aversion ($\alpha = .70$) and Perceived Infectability ($\alpha = .88$) subscales of the Perceived Vulnerability to Disease scale (Duncan et al., 2009).

Results and discussion

Trials on which participants moved the joystick in the incorrect direction and trials on which the latency was above or below 3 standard deviations from a participant's mean latency were excluded. Average reaction times were analyzed using an analysis of variance with factors of movement direction (congruent vs. incongruent; between subjects) and illness recency (the categorical measure: recently ill vs. not recently ill; between subjects). This analysis revealed a main effect of movement direction, $F(1, 102) = 15.57$, $p < .001$, $\eta_p^2 = .13$; participants were quicker when arm movements were congruent than when they were incongruent with disfigurement bias. However, this effect was qualified by a significant interaction between movement direction and illness recency, $F(1, 102) = 9.37$, $p = .003$, $\eta_p^2 = .08$. Participants who had been ill within the past week ($n = 35$) were quicker when arm movements were congruent ($M = 848$ ms, $SD = 115$) than when they were incongruent ($M = 1{,}193$ ms, $SD = 423$) with disfigurement bias, $F(1, 102) = 18.33$, $p < .001$, $\eta_p^2 = .15$; participants who had not been recently ill ($n = 71$) did not show this effect, $F < 1$ (bias-congruent trials: $M = 896$ ms, $SD = 129$; bias-incongruent trials: $M = 940$ ms, $SD = 247$). (See the Supplemental Material available online for results using an alternative categorization scheme.)

Analysis using the continuous measure of illness recency revealed an interaction between movement direction and illness recency, $F(1, 102) = 4.82$, $p = .03$, $\eta_p^2 = .05$. Simple-slopes

analyses revealed that participants who had recently been ill (1 *SD* above the mean; $M = 3.12$, $SD = 1.66$) were quicker when arm movements were congruent than when they were incongruent with disfigurement bias, $F(1, 102) = 13.45$, $p < .001$, $\eta_p^2 = .12$; no effect of movement direction was observed among participants who had not been recently ill (1 *SD* below the mean), $F < 1$ (see Fig. 2).

Scores on the Germ Aversion and Perceived Infectability subscales were uncorrelated with the continuous measure of illness recency (ps > .16) and failed to discriminate between participants who had and had not been ill within the past week, Fs < 1. Moreover, interactions between movement direction and illness recency remained significant after controlling for those measures, ps < .04.

Study 2 supports the hypothesis that recent illness is accompanied by heightened avoidance of individuals displaying heuristic disease cues. Participants who had recently been sick were quicker to engage avoidance movements than to engage approach movements in response to disfigured individuals; this bias was not observed among participants who had not recently been sick. As in Study 1, these findings could not be explained by conscious concerns about disease vulnerability. The findings suggest that activation of the BIO system through recent illness facilitates behavioral responses designed to avoid potential health threats.

General Discussion

The current findings are the first empirical evidence for the hypothesis that activation of the BIO system facilitates activation of the BEH system. Participants who had recently been ill (and therefore experienced activation of the BIO system) displayed heightened attention to and avoidance of individuals displaying heuristic disease cues. These effects were over and above the effects of overt concerns about disease vulnerability. Indeed, recently ill participants were no more likely to consciously worry about becoming sick than were participants who had not been recently ill. Thus, the relationship between recent illness and activation of the BEH system may reflect a fundamental and automatic interface between biological and psychological mechanisms designed to protect against disease.

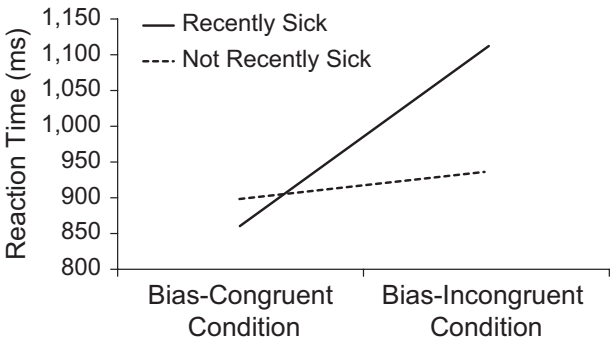

Fig. 2. Results from Study 2: mean reaction time in the approach-avoidance task as a function of movement direction (congruent vs. incongruent with disfigurement bias) and continuously measured illness recency (recently sick = 1 *SD* above the mean; not recently sick = 1 *SD* below the mean).

These studies were not designed to answer questions about the biological mechanisms linking the BIO and BEH systems. One possibility is that, because it tends to increase susceptibility to new infections (van der Sluijs et al., 2004), interleukin-10 may be a particular aspect of the BIO system that promotes activation of the BEH system. However, the BIO system is complex, and many factors are likely to shape interactions between the BIO and BEH systems. Indeed, one's susceptibility to infection postillness may depend on the type of illness one was infected with and the time since initial infection with that illness. For example, interferons released in response to a viral infection may, for a brief time, protect against similar viral infections while increasing susceptibility to new bacterial infections (Sun & Metzger, 2008). This may have consequences for when and how the BEH system is activated and expressed after an initial infection.

In addition to investigating specific biological processes mediating the link between the BIO and BEH systems, future research should address potential limitations of our studies. One limitation is that although we ruled out effects of conscious disease concerns, we did not directly investigate the potential role of nonconscious goals. Another limitation involves the reliance on self-reported measures of illness recency: There may be slippage between such measures and the actual timing of the immune system's response. Accounting for these limitations in future research will provide a clearer understanding of the links between the BIO and BEH systems.

Nevertheless, the current findings provide important insight into the ways in which humans evolved to overcome disease threats. Combined with recent findings indicating that activation of the BEH system facilitates activation of the BIO system (Schaller et al., 2010), our findings suggest a bidirectional and compensatory relationship between these two systems. This relationship likely evolved to provide maximal protection against infection when disease threats are most threatening; if one system fails (e.g., the BIO system is weakened), the other system provides an alternative solution (e.g., avoiding potential sources of contagion). Thus, our findings illuminate a potentially adaptive interaction between psychological and biological systems.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

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